

The Combined Radar-Radiometer Algorithm— GPM Version 06X

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Kwo-Sen Kuo, Dave Randel, Bart Kelley, Dave Bolvin, Liang Liao, Bob
Meneghini, Walt Petersen, Pierre Kirstetter

with support from

the Radar and Radiometer Algorithm Teams, the GV Team,
WG's, and Precipitation Processing System Personnel
(special kudos to Larry Woltz, Patty McCaughey, John Kwiatkowski,
and John Stout)

Primary Activities

The changes/additions to algorithm:

- ◆ adapt the Combined Algorithm to HS Ka data in the outer swath;
i.e., use Ku / Ka / GMI observations over full DPR swath (V06X).
- ◆ produce a precip profile / brightness temperature database
more directly suited to Radiometer Algorithm applications.



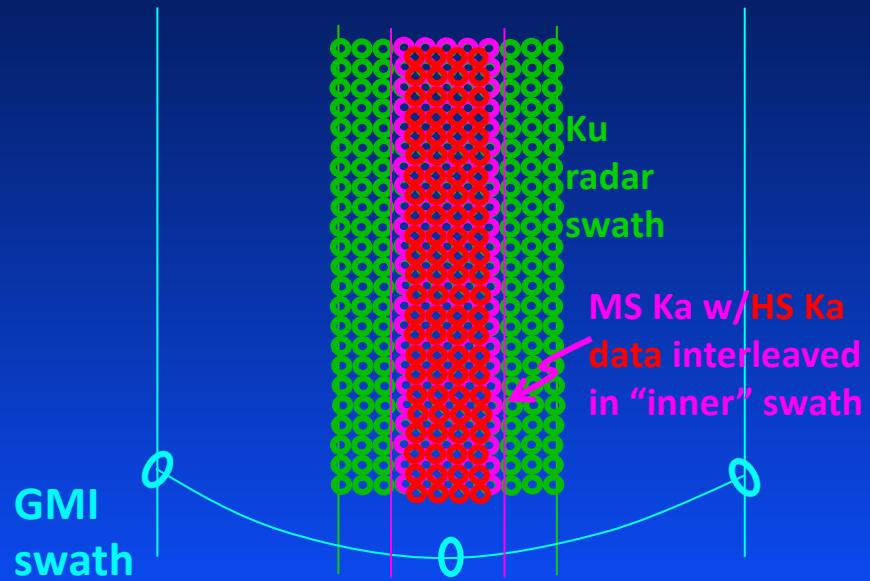
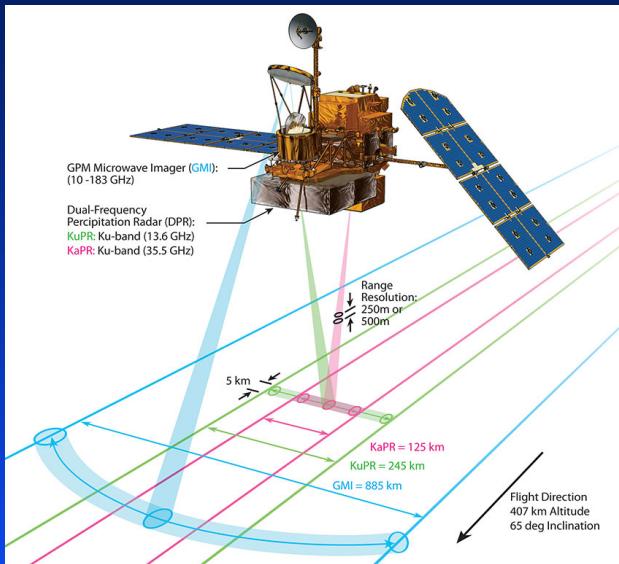
Now that V06X input from radar team has stabilized, trying to understand the impact of outer-swath Ka HS data on precip estimates.

Adaptation to HS Ka Data in the Outer Swath (Level 2)

Old system:

NS mode
Ku + GMI
full swath

MS mode
Ku + Ka + GMI
inner swath

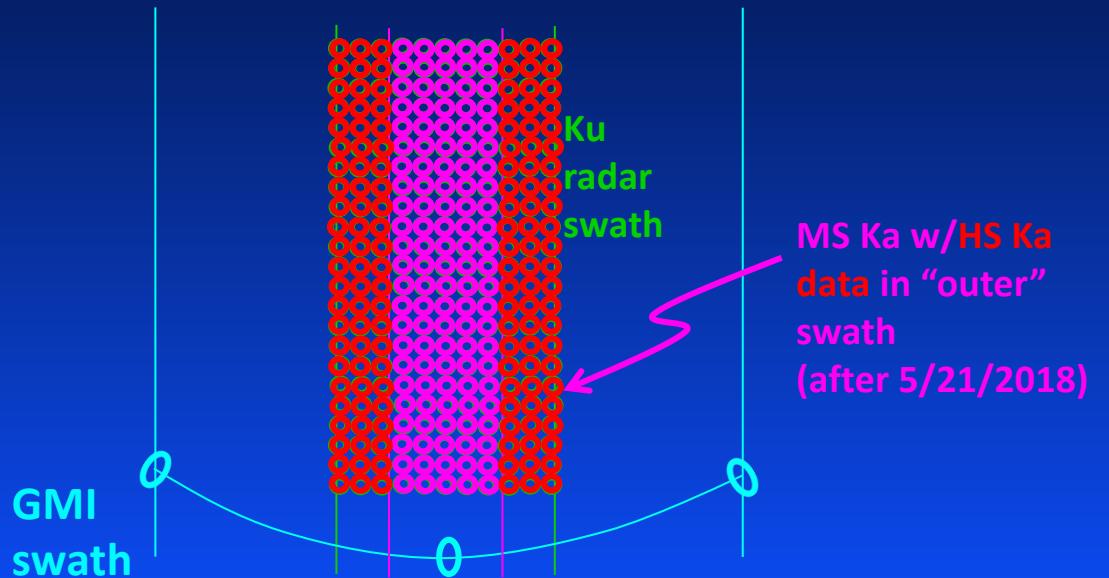
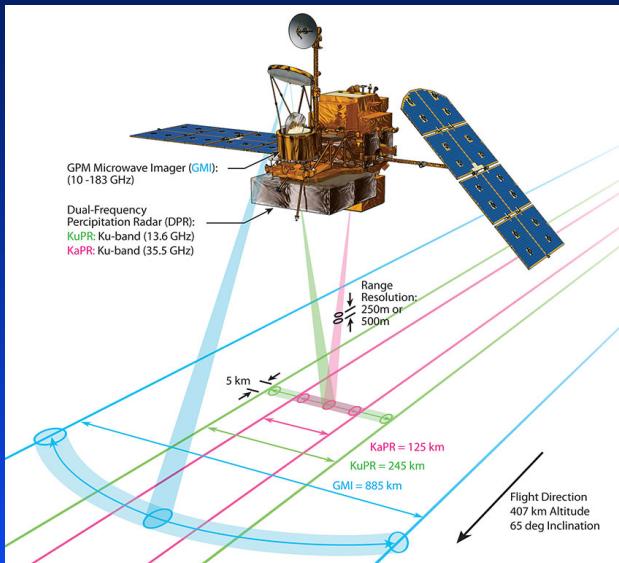


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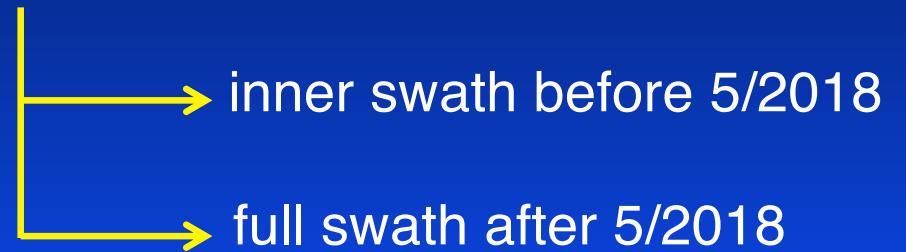
New system:

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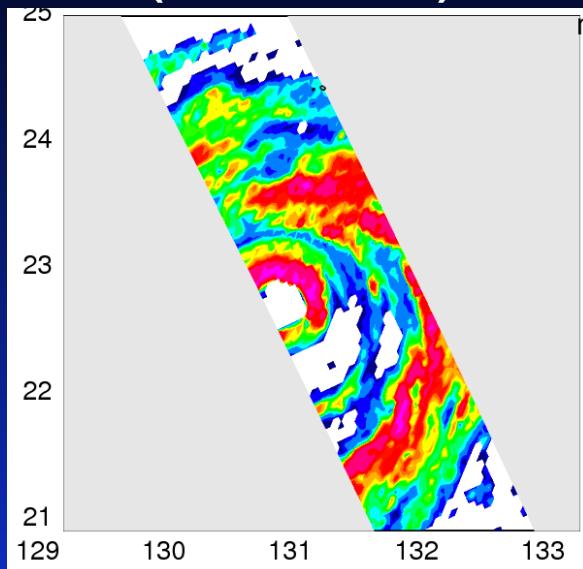
FS mode

Ku + Ka + GMI

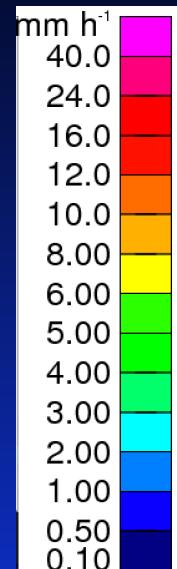
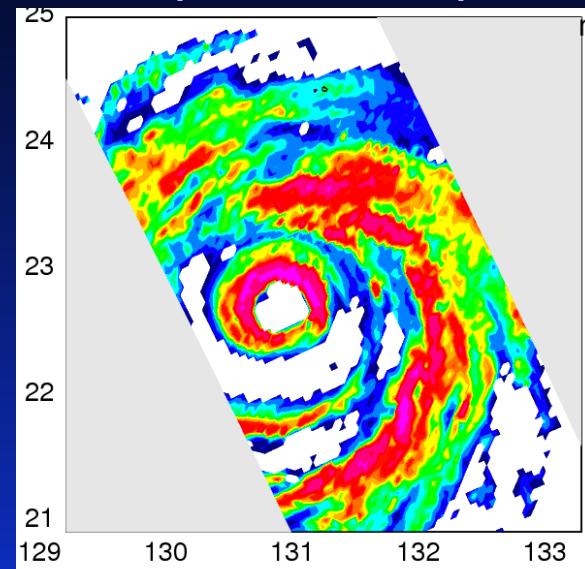


Example of Super Typhoon Maria (Jul. 9, 2018)

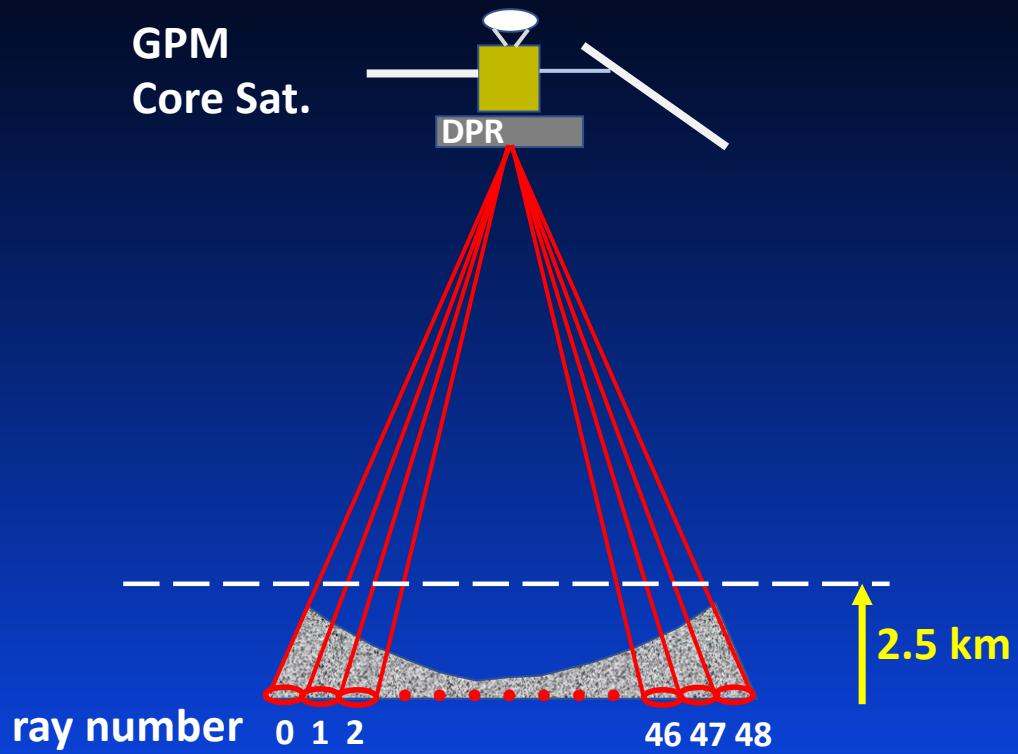
V06A MS Mode
(Ku+Ka+GMI)



V06X FS Mode
(Ku+Ka+GMI)



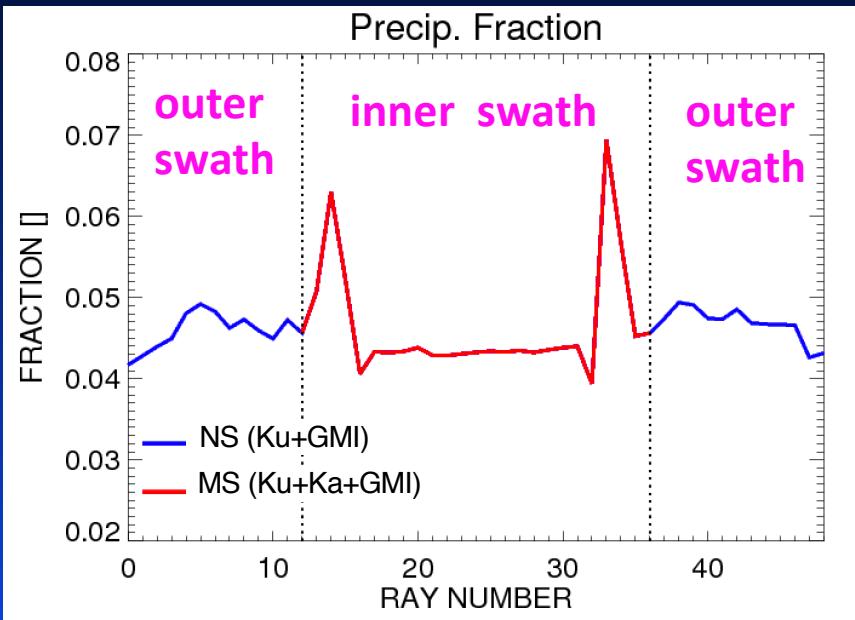
Calculating Angle-Means at 2.5 km over Ocean



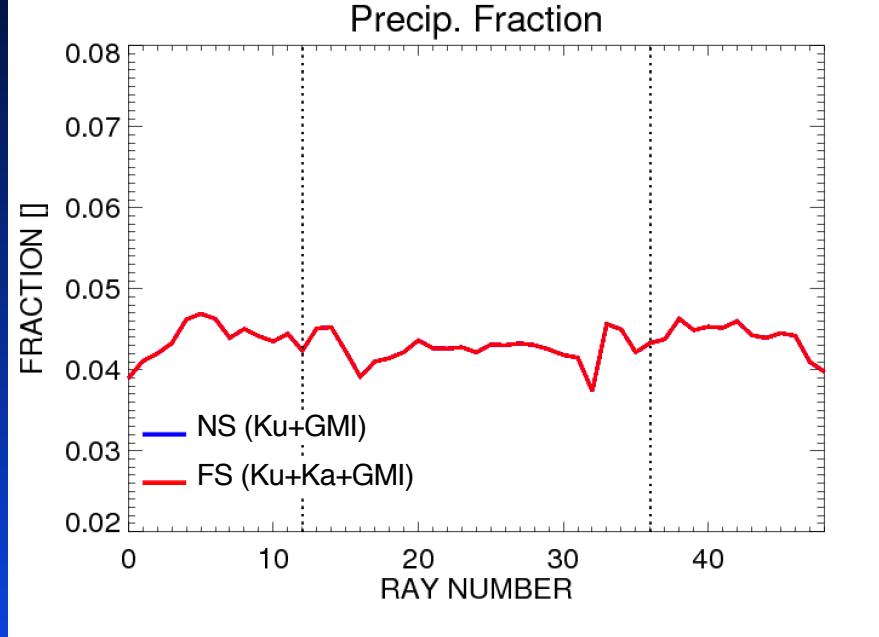
Do we see any anomalies across the swath?

- June 2018 2.5 km mean precip fraction at each scan angle over ocean:

V06A



V06X

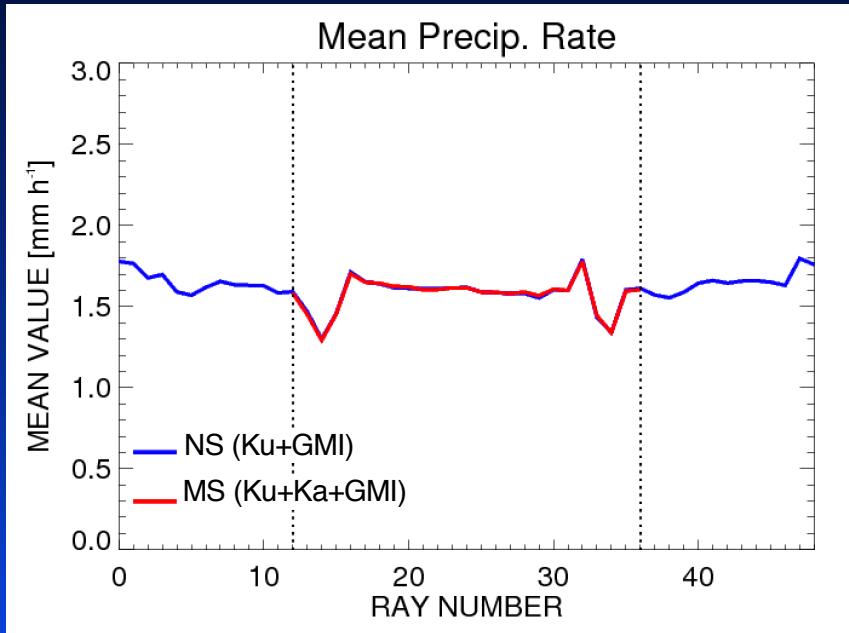


- impact of sidelobe anomalies obvious in V06A; controlled in V06X.

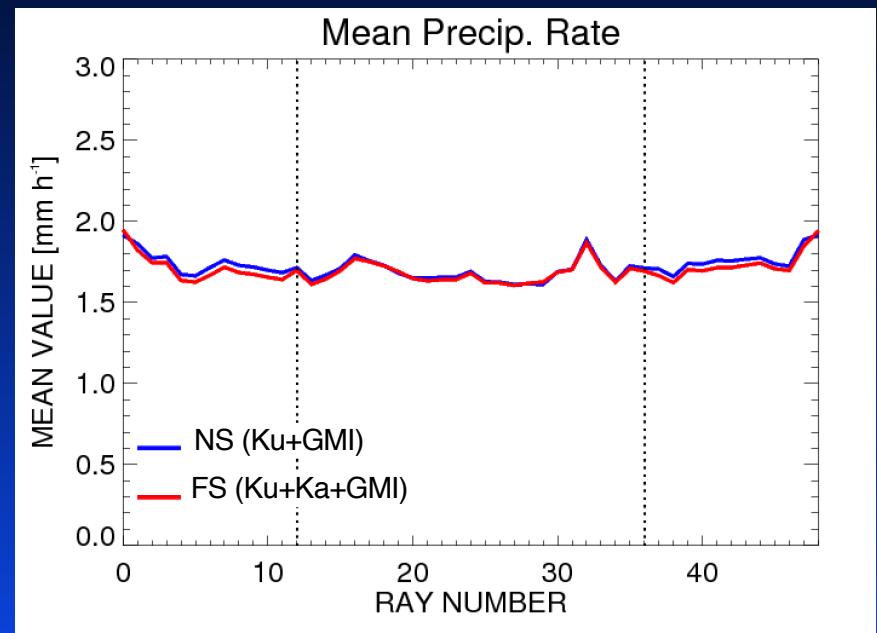
Do we see any anomalies across the swath?

- June 2018 2.5 km conditional mean precip rate at each scan angle over ocean:

V06A



V06X

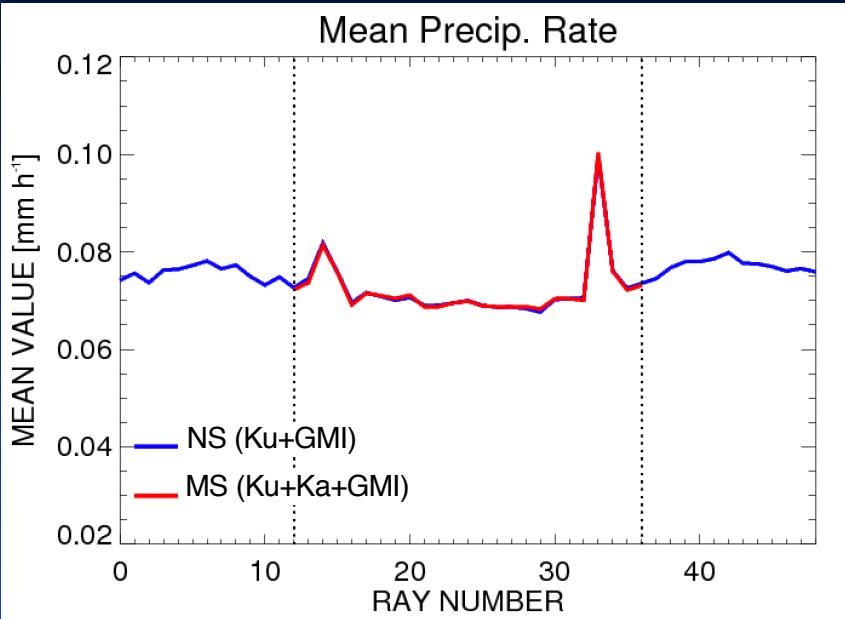


- aside from sidelobe anomaly effects, V06A and V06X means look very similar.

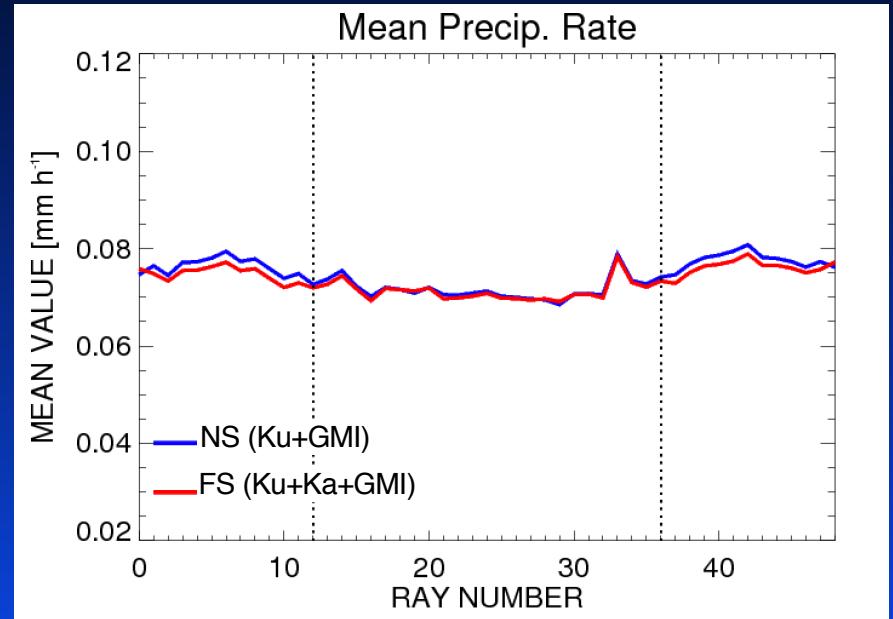
Do we see any anomalies across the swath?

- June 2018 2.5 km unconditional mean precip rate at each scan angle over ocean:

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V06X



- aside from sidelobe anomaly effects, V06A and V06X means look very similar.



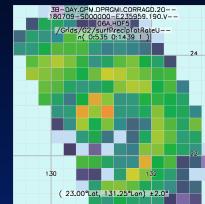
More generally, why do we see trends of conditional rain between inner and outer swaths?

...implications for V07?

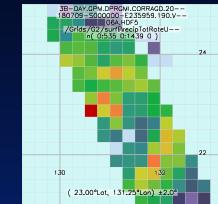
Adaptation to HS Ka Data in the Outer Swath (Level 3)

Old system:

Ku + GMI
gridded
full swath



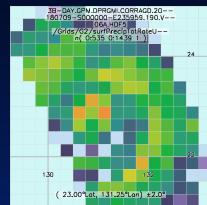
Ku + Ka + GMI
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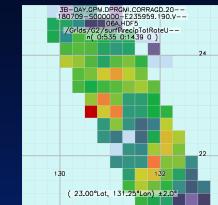
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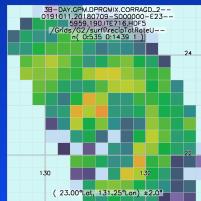
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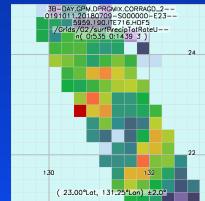
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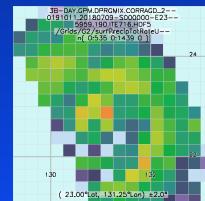


gridded
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Ku + Ka + GMI

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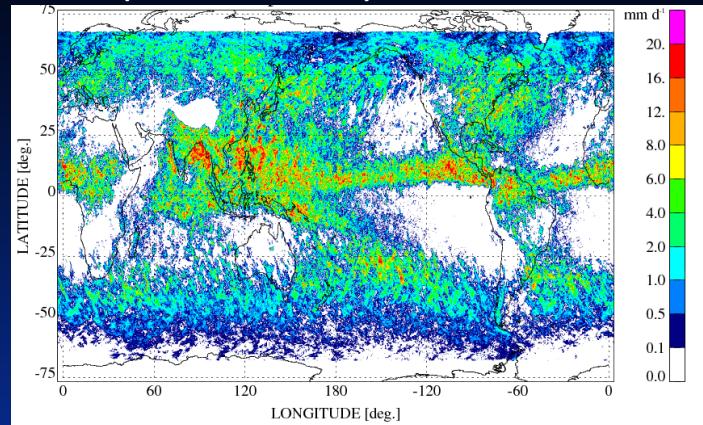


gridded
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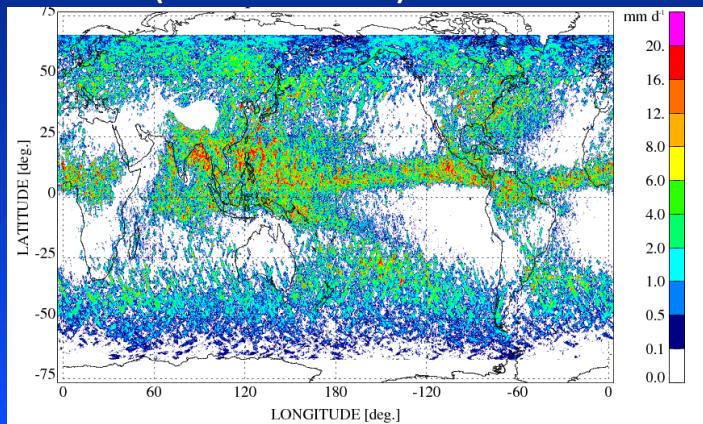


V06X JJA 2018 Averages of FS Full vs Inner Swath

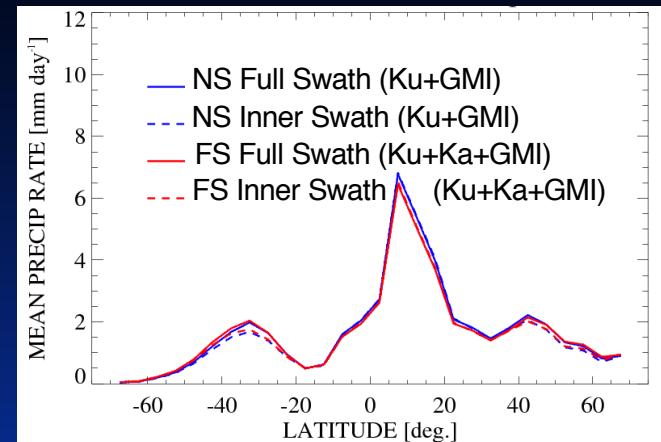
FS Full (Ku+Ka+GMI) 3.0 km Estimates



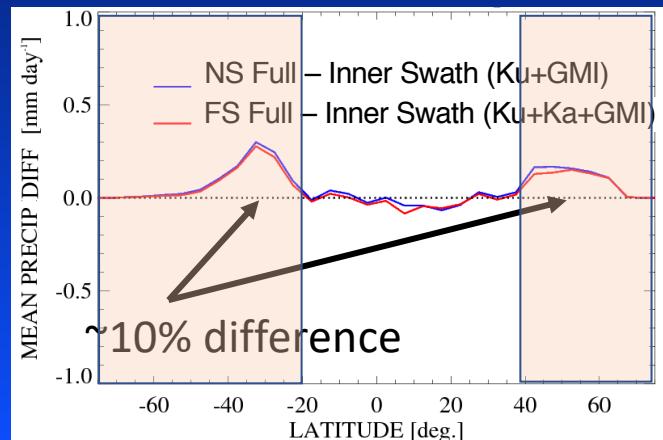
FS inner (Ku+Ka+GMI) 3.0 km Estimates



NS and FS Zonal Means over Ocean

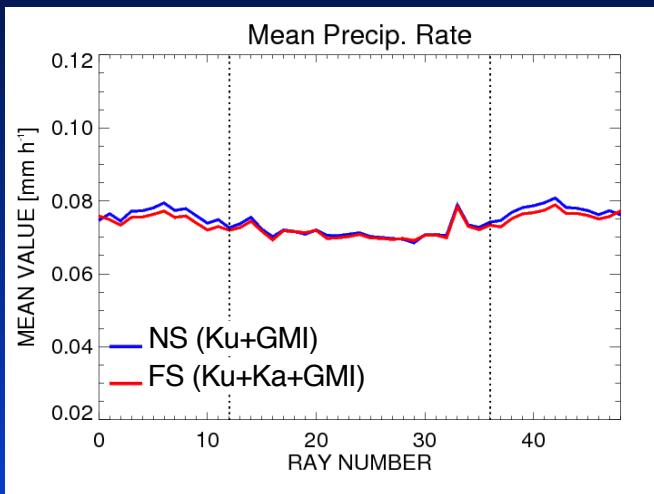


NS and FS Zonal Full – Inner Differences



Calculate Angle-Means but for Different Regions over Ocean

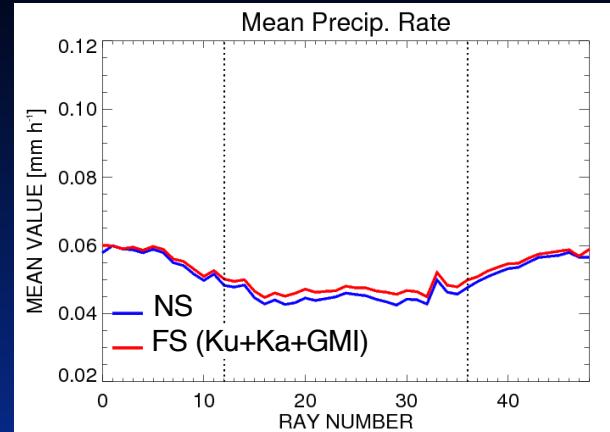
Global



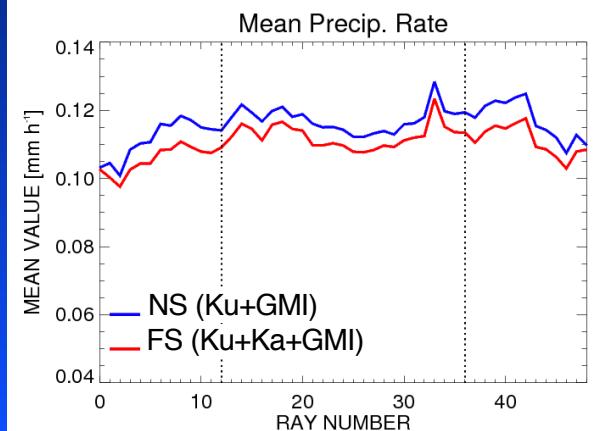
storm tracks

“lower” latitudes

Region lat < 20 S or lat > 40 N



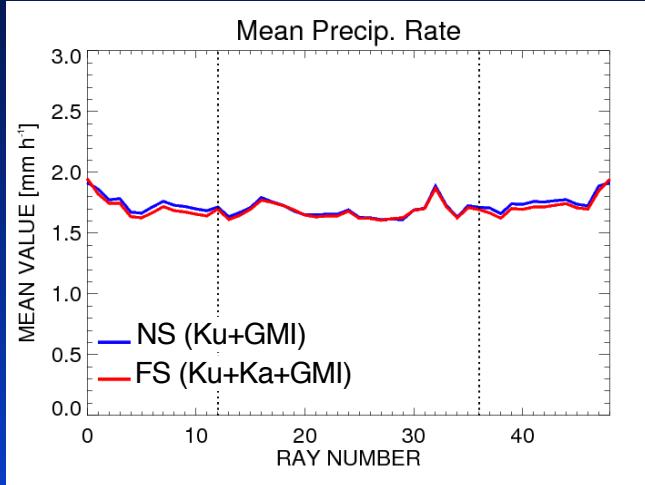
Region lat > 20 S and lat < 40N



Calculate Angle-Means but for Different Regions over Ocean

(Conditional Rates)

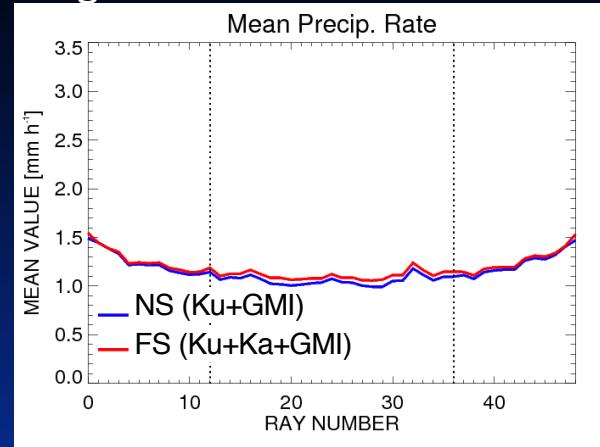
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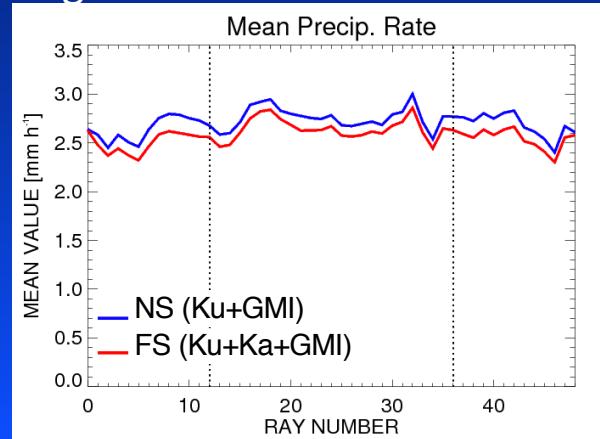
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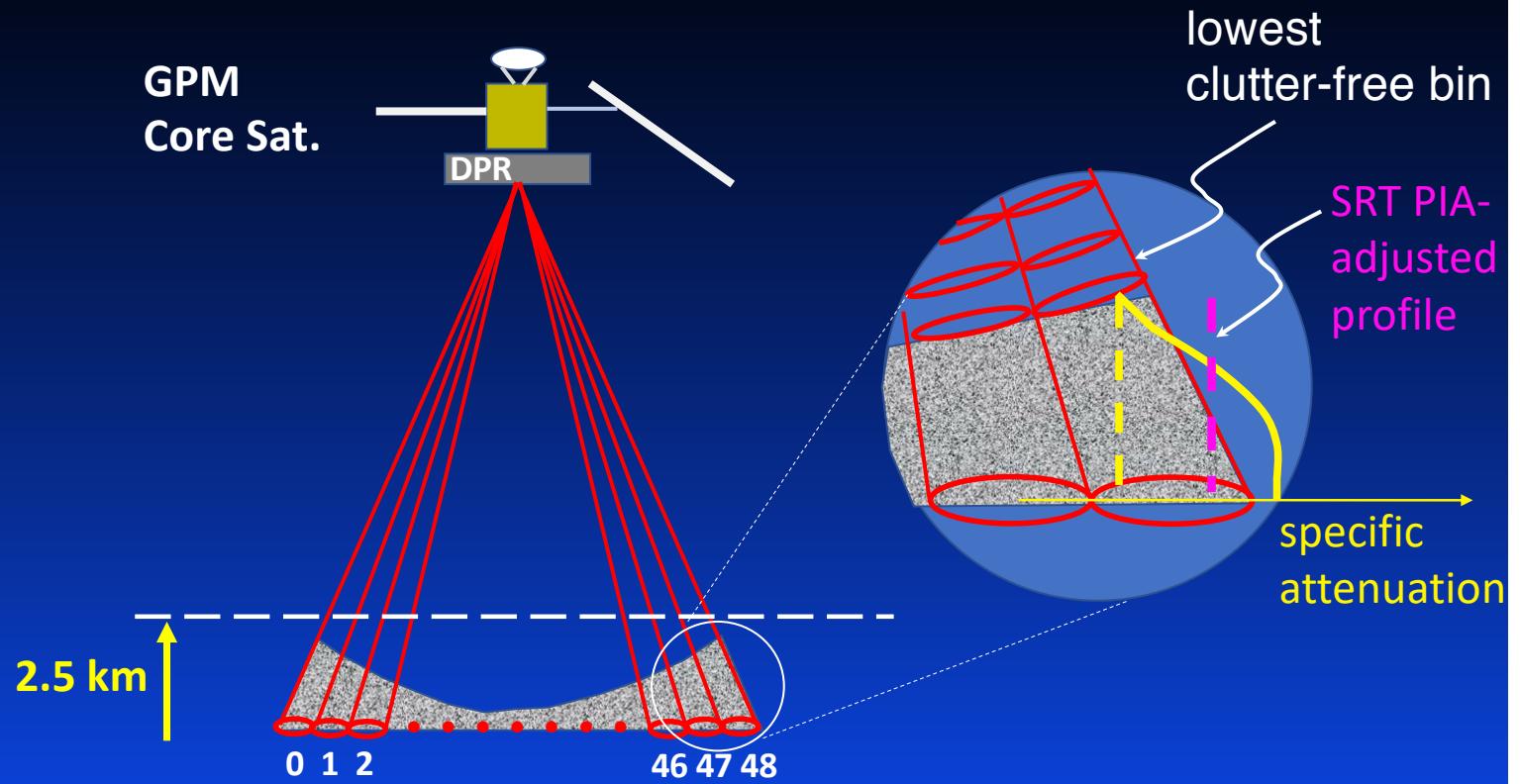
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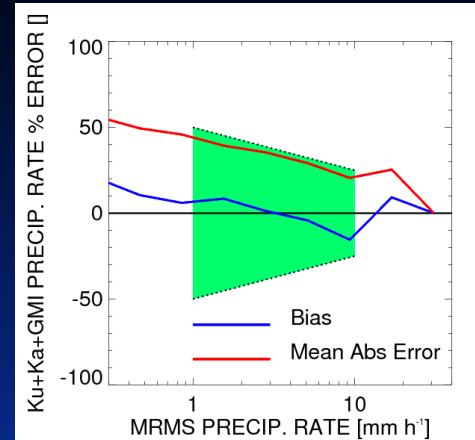
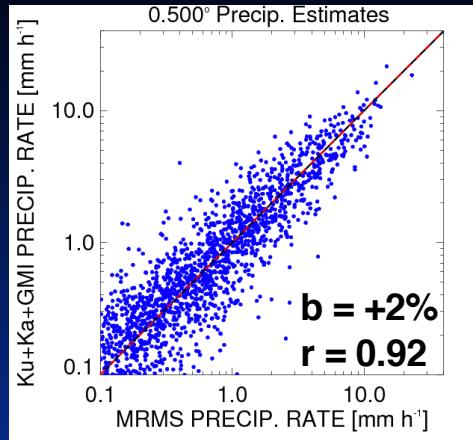
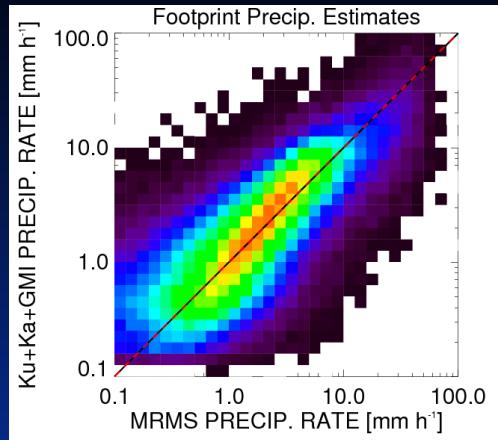


Hypothesis for High Bias in Outer-Swath Bins

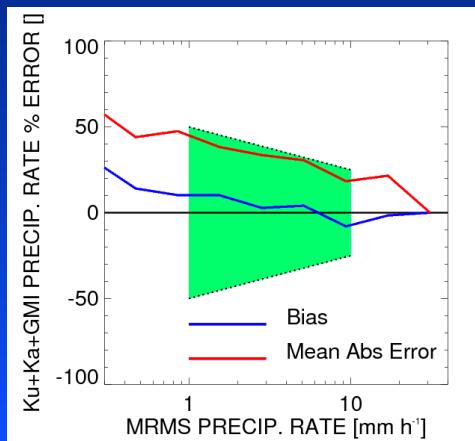
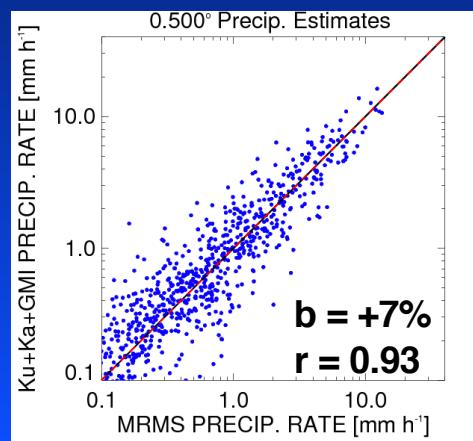
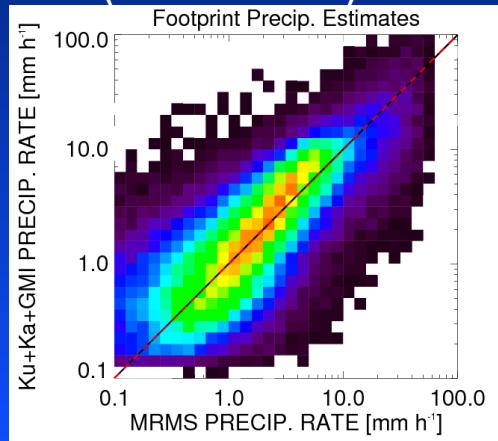


FS Comparisons with MRMS Calibrated Radar (JJA 2018 only)

V06X FS (Ku+Ka+GMI) Full Swath



V06X FS (Ku+Ka+GMI) Inner Swath



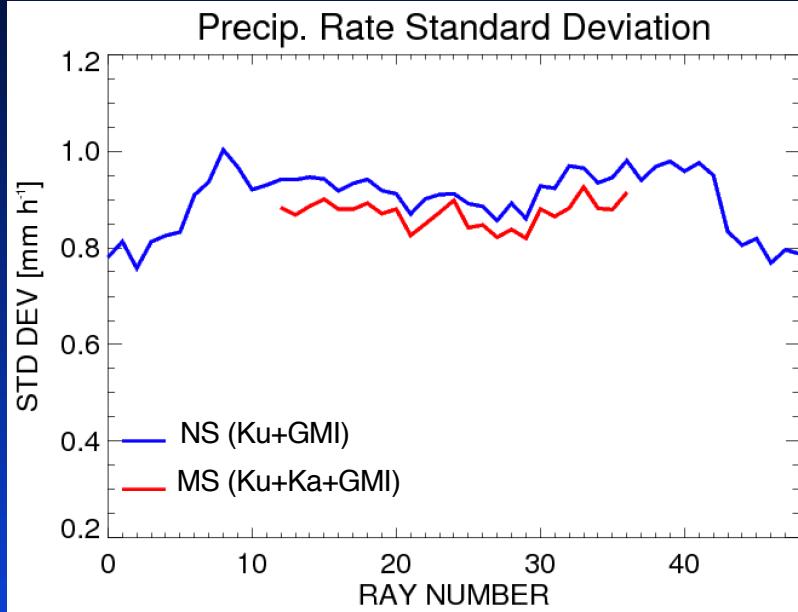
Concluding Remarks

- we have adapted the L2/L3 code to HS Ka data in the outer swath.
- so far, no obvious discontinuities across the Ka MS/HS swath boundary; trends of Ku + Ka + GMI estimates follow trends of Ku + GMI.
- would like to give the V06X algorithm a more thorough check: larger set of data; other variables, etc.
- specialized radiance module added to MS/FS processing stream – will adjust ice-phase precipitation similar to what is done by the Radiometer Team.
- we will return to “science” improvements in V07; i.e. address low bias over land etc.

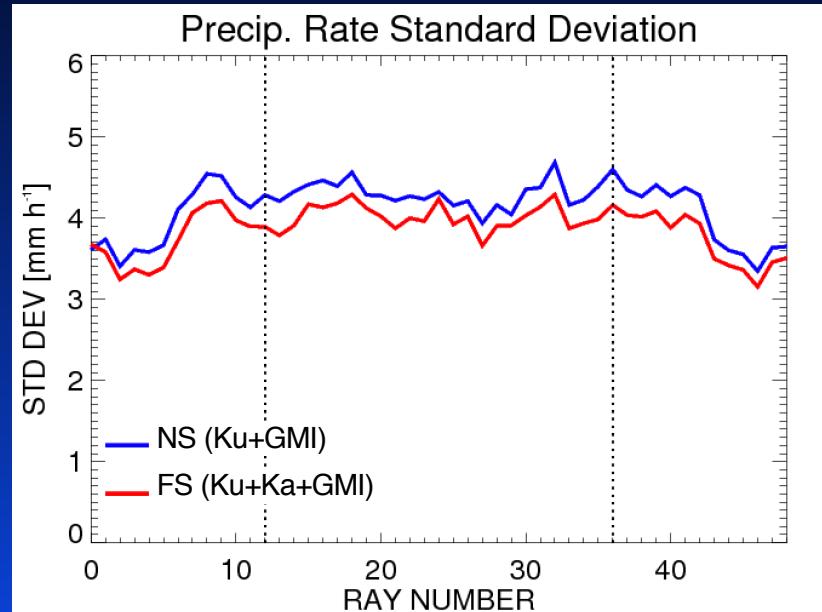
Do we see any anomalies across the swath?

- June 2018 2.5 km conditional precip std. dev. at each scan angle over ocean:

V06A



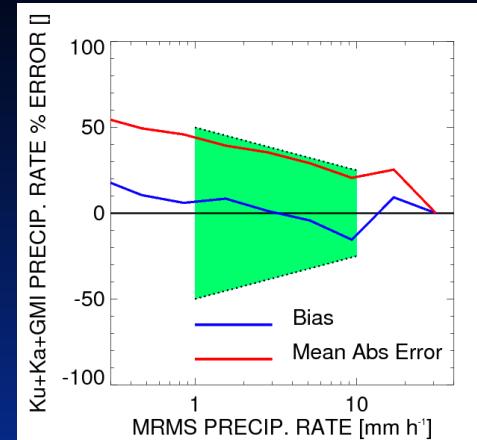
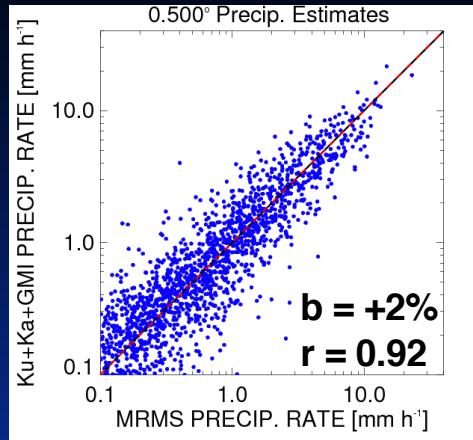
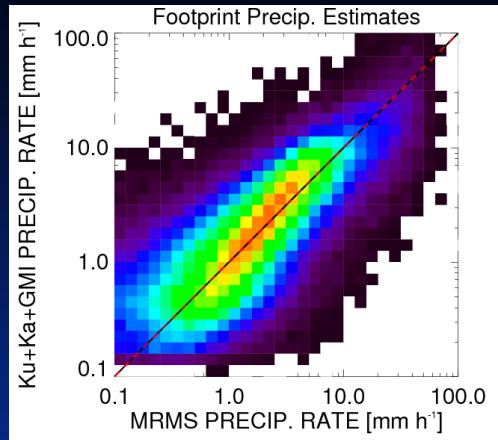
V06X



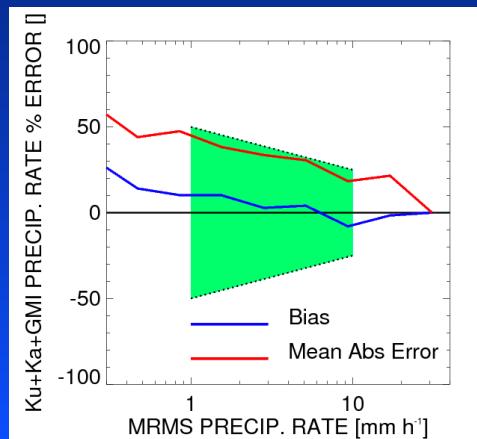
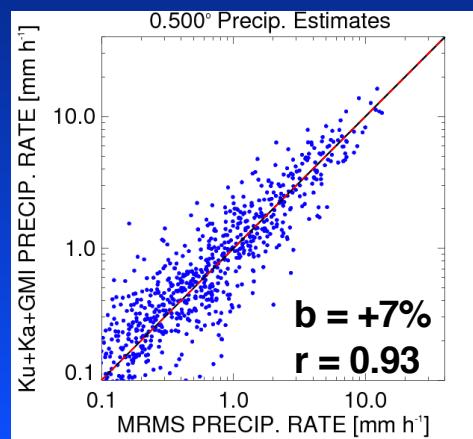
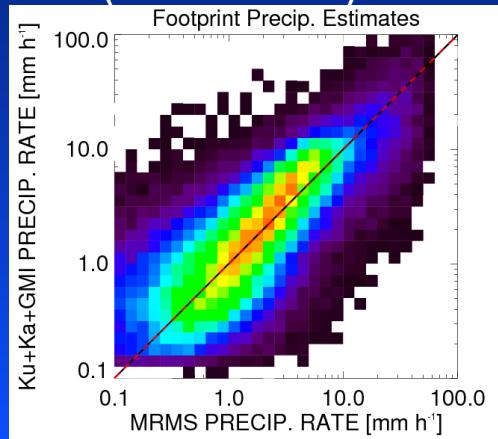
- falloff in variation at swath edge likely due to lack of GMI information.

FS Comparisons with MRMS Calibrated Radar (JJA 2018 only)

V06X FS (Ku+Ka+GMI) Full Swath

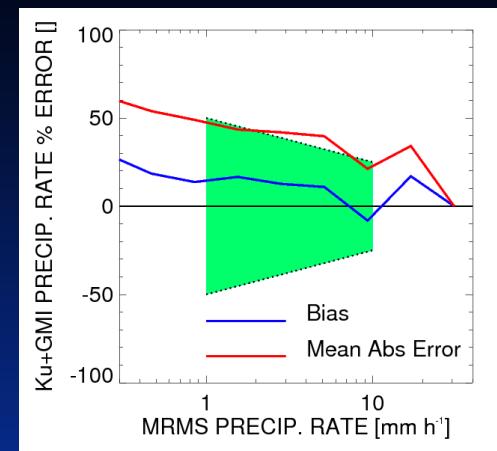
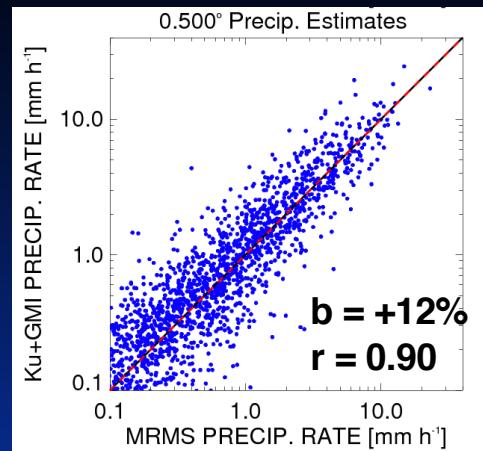
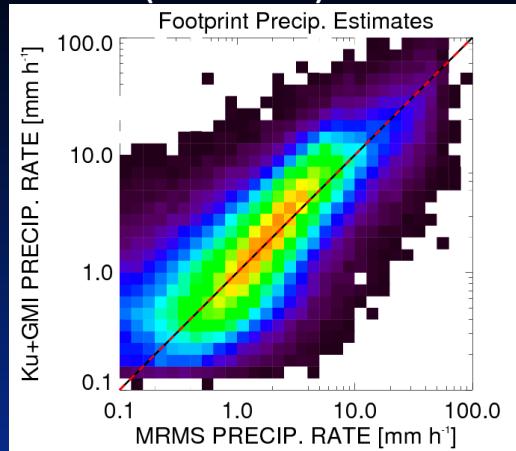


V06X FS (Ku+Ka+GMI) Inner Swath

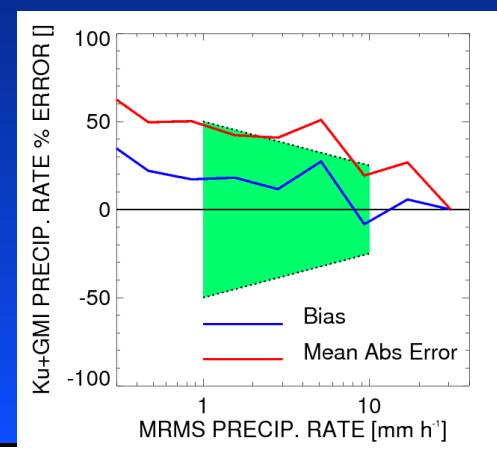
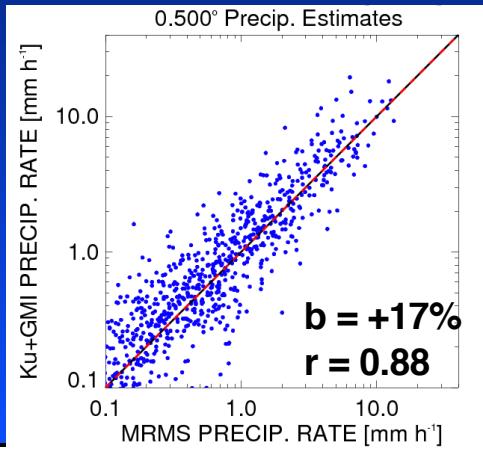
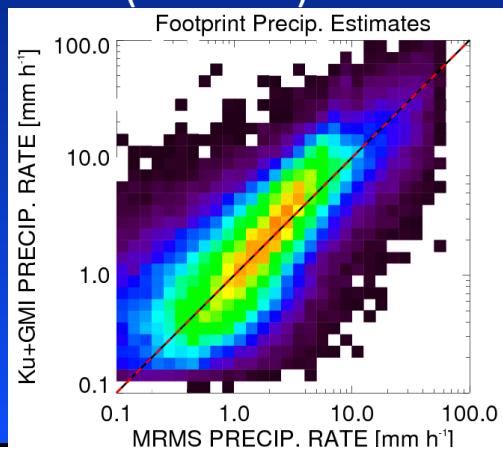


NS Comparisons with MRMS Calibrated Radar (JJA 2018 only)

V06X NS (Ku+GMI) Full Swath



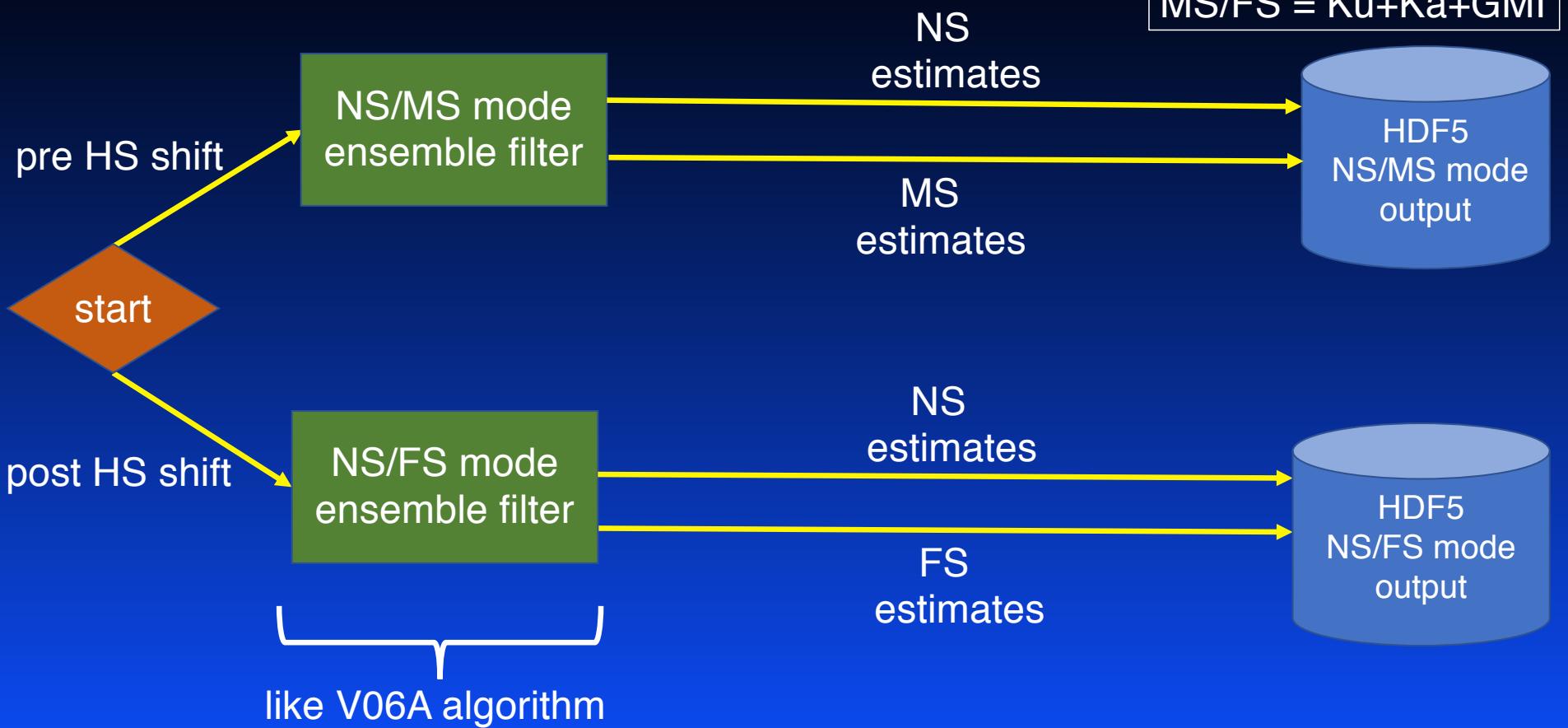
V06X NS (Ku+GMI) Inner Swath



extras

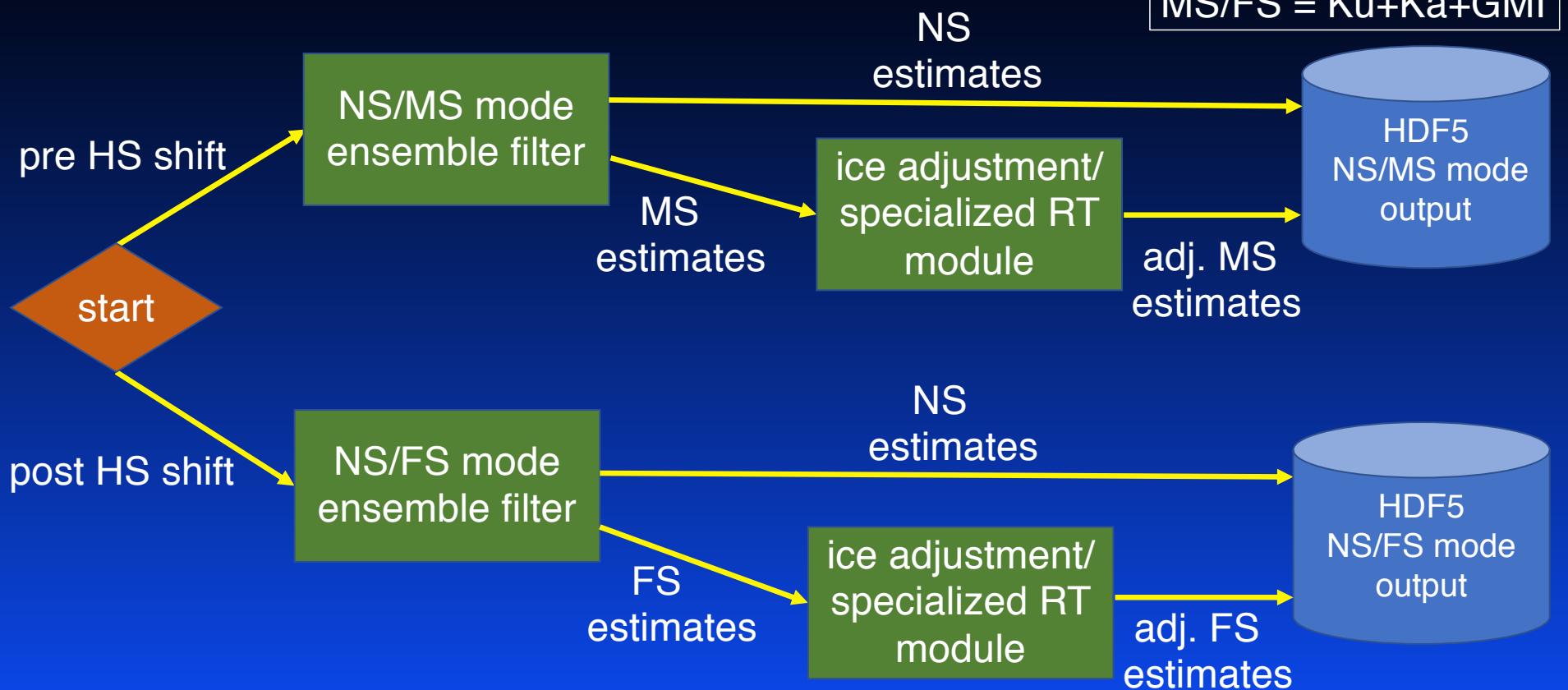
L2 Workflow Diagram

NS = Ku+GMI
MS/FS = Ku+Ka+GMI



L2 Workflow Diagram

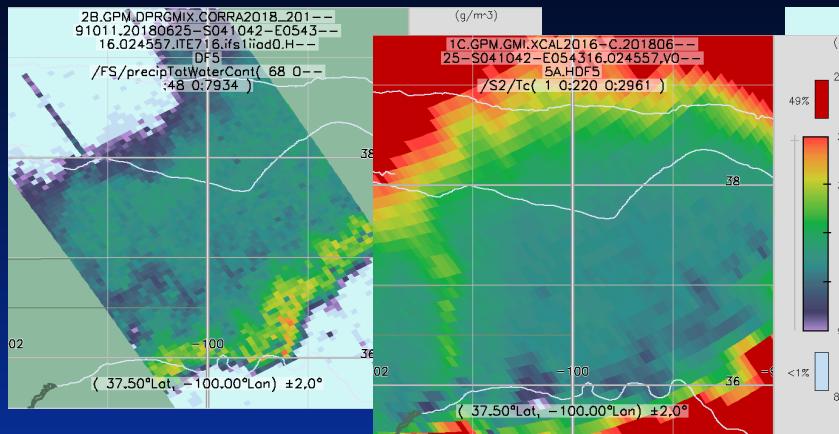
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Effects of Precipitating Ice Adjustment

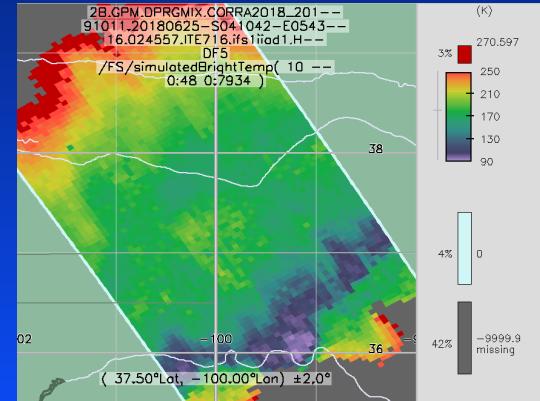
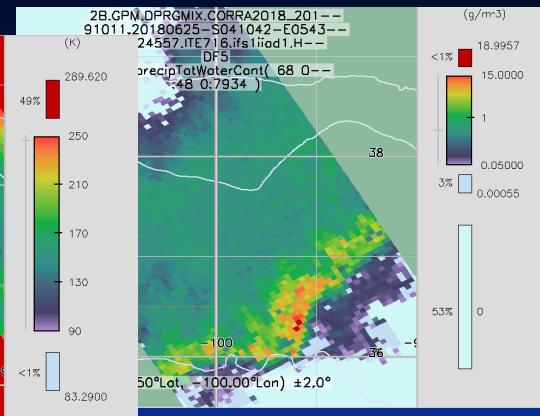
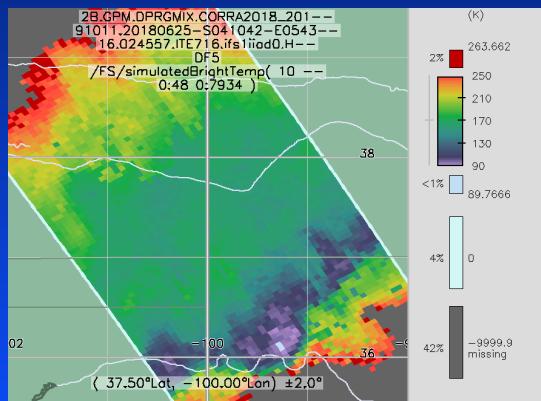
V06X

Precip at
~4.5 km

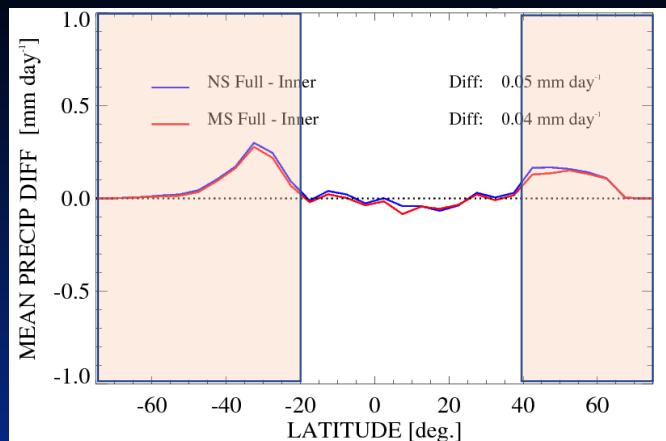


Adjusted V06X

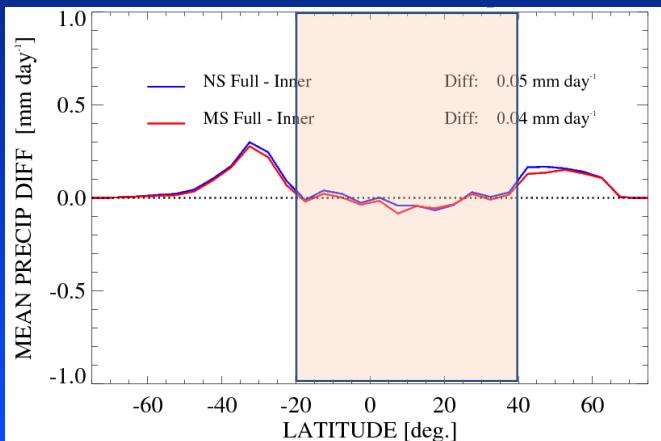
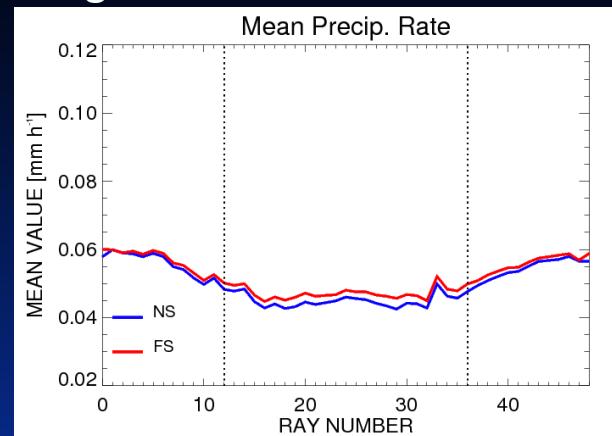
Simulated
166 GHz H



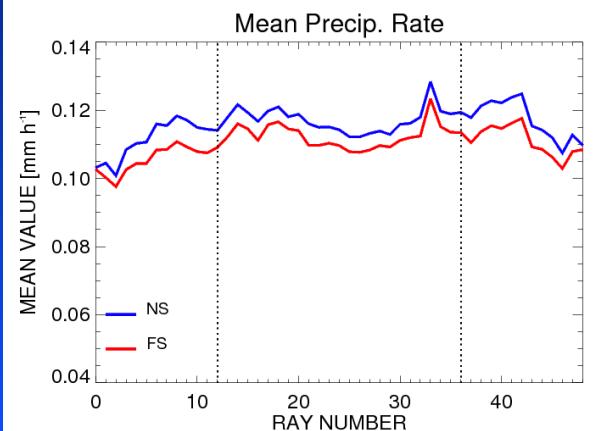
V06X JJA 2018 Averages of FS Full vs Inner Swath



Region lat < 20 S or lat > 40 N



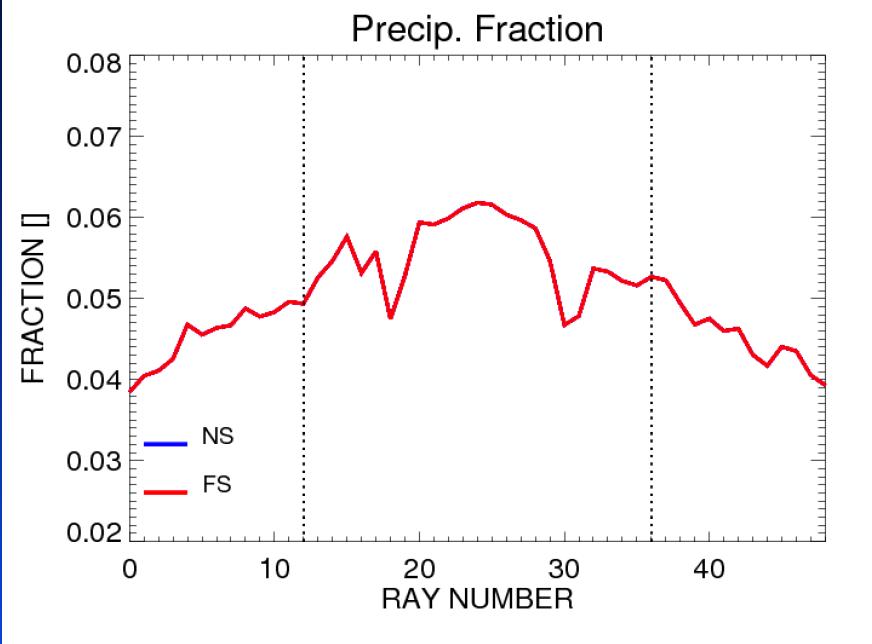
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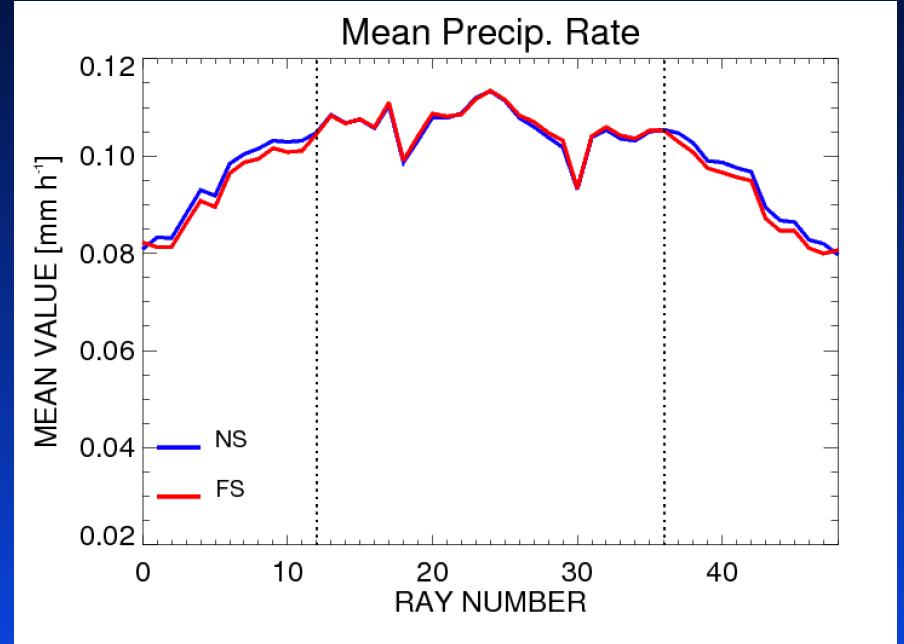
Do we see any anomalies across the swath?

- June 2018 mean surface rain fraction and rate at each scan angle over ocean:

V06X



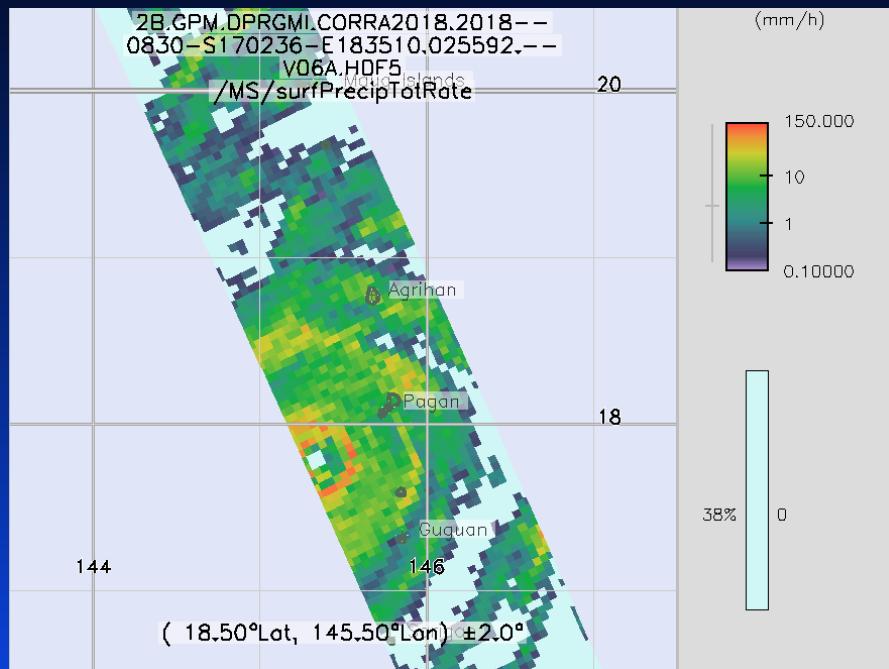
V06X



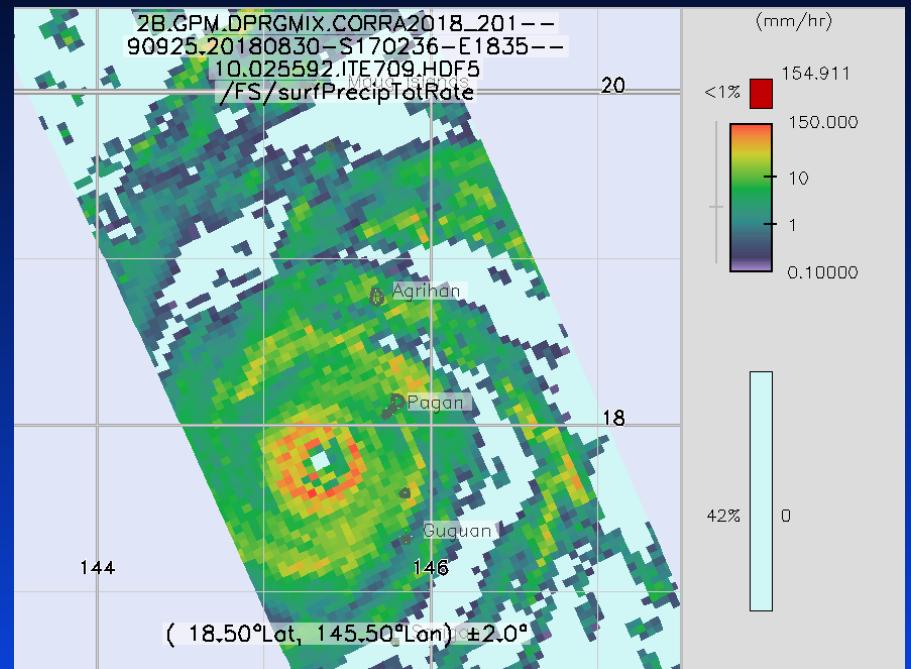
- need estimated surface rain rate product, but how good will that be?

Example of Super Typhoon Jebi (Aug. 30, 2018)

V06A MS Mode (Ku+Ka+GMI)

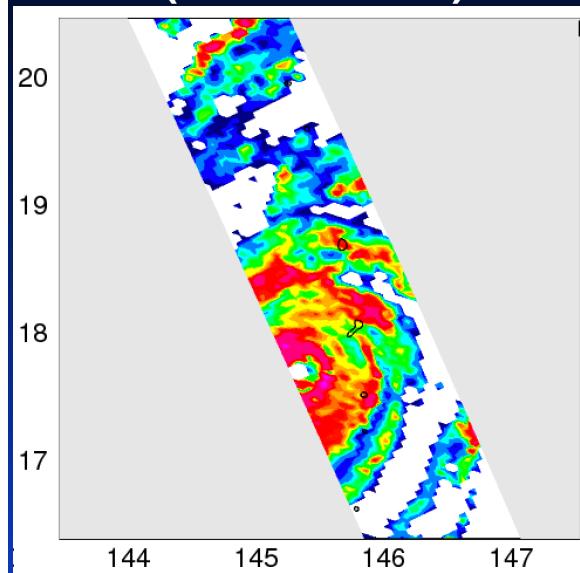


V06X FS Mode(Ku+Ka+GMI)

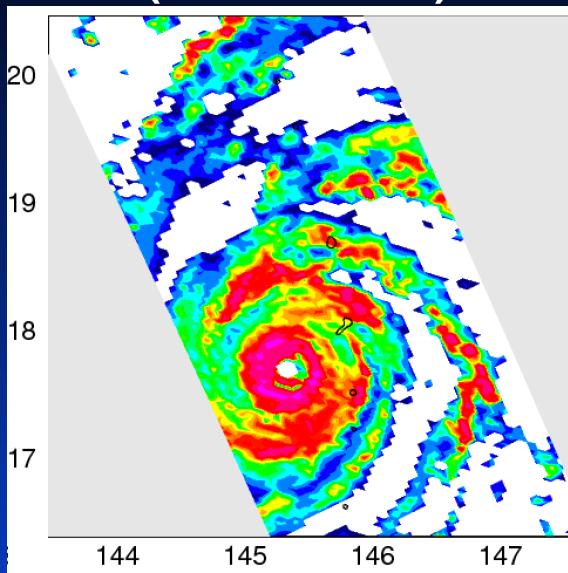


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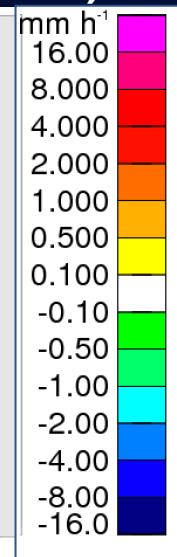
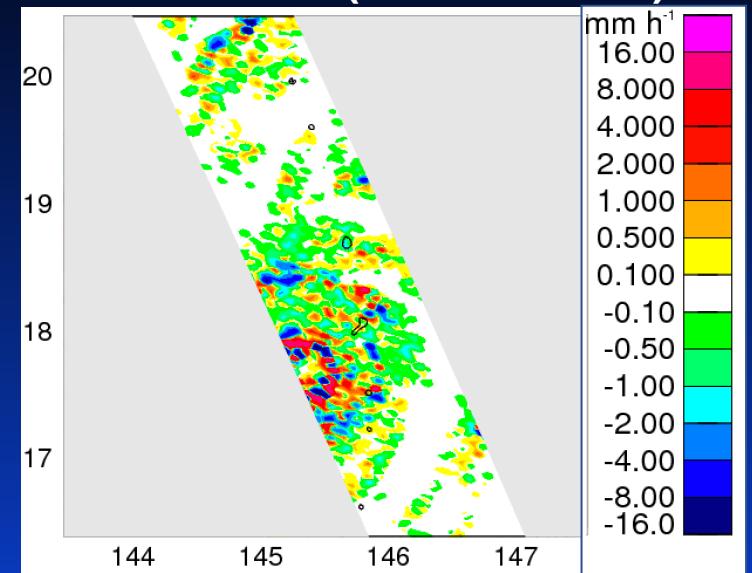
V06A MS Mode
(Ku+Ka+GMI)



V06X FS Mode
(Ku+Ka+GMI)

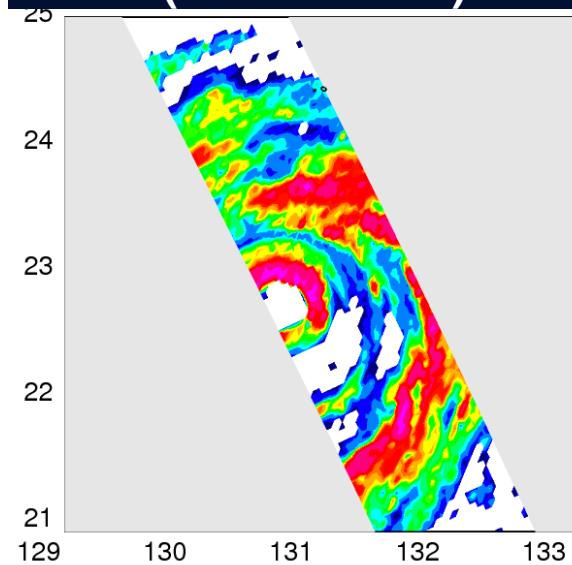


Difference (V06X – V06A)

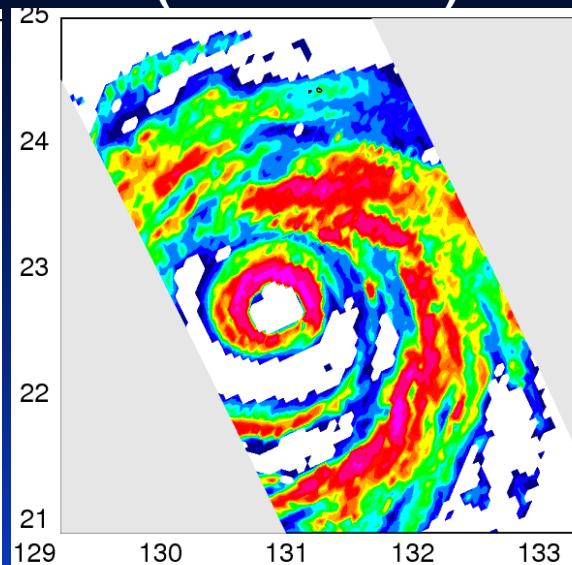


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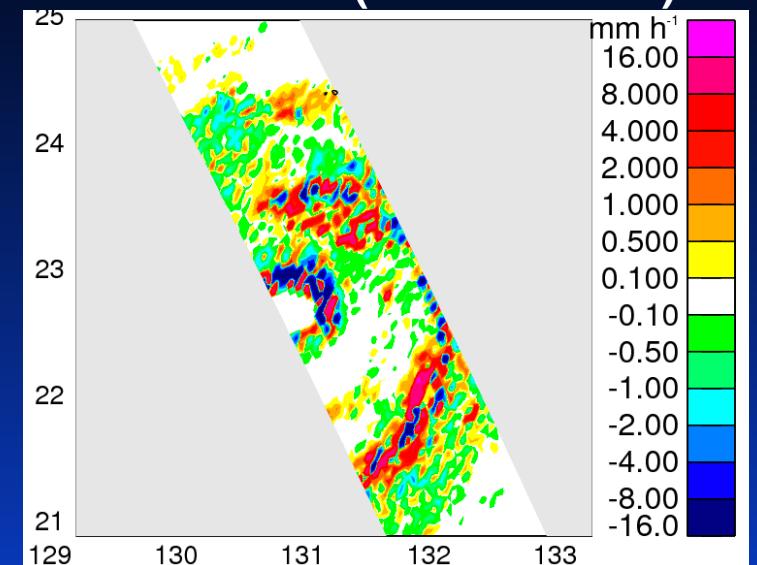
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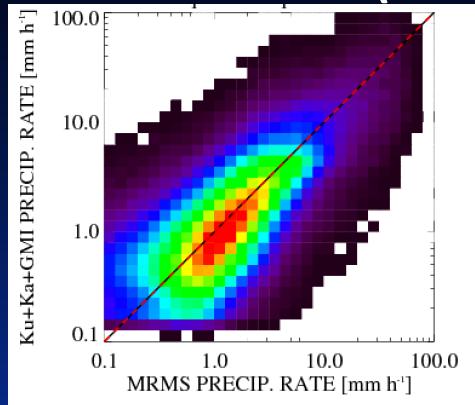


Difference (V06X – V06A)

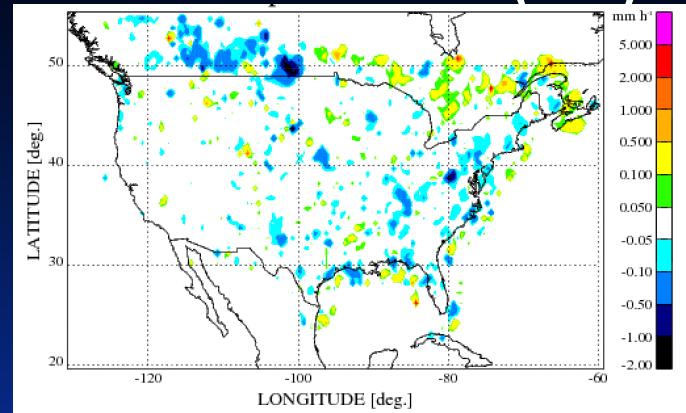


September, 2014 - August, 2015, GPM vs MRMS Comparisons

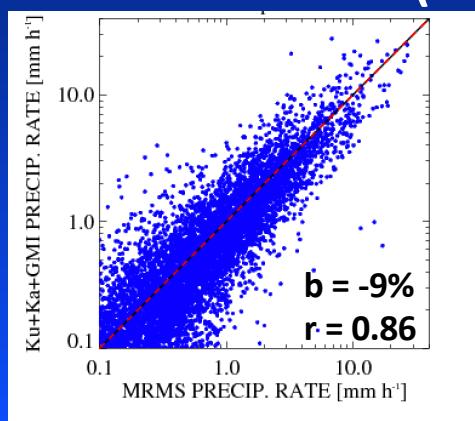
GPM V06 vs. MRMS (Footprint)



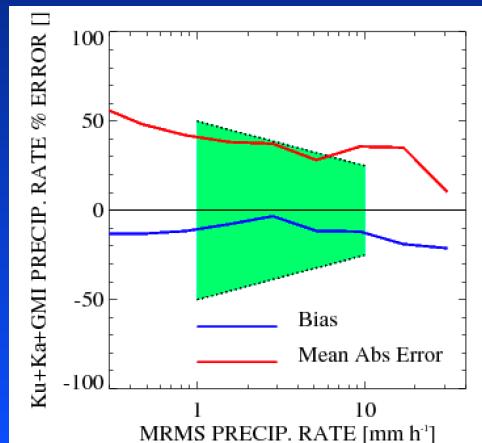
GPM V06 – MRMS (0.5°)



GPM V06 vs. MRMS (0.5°)



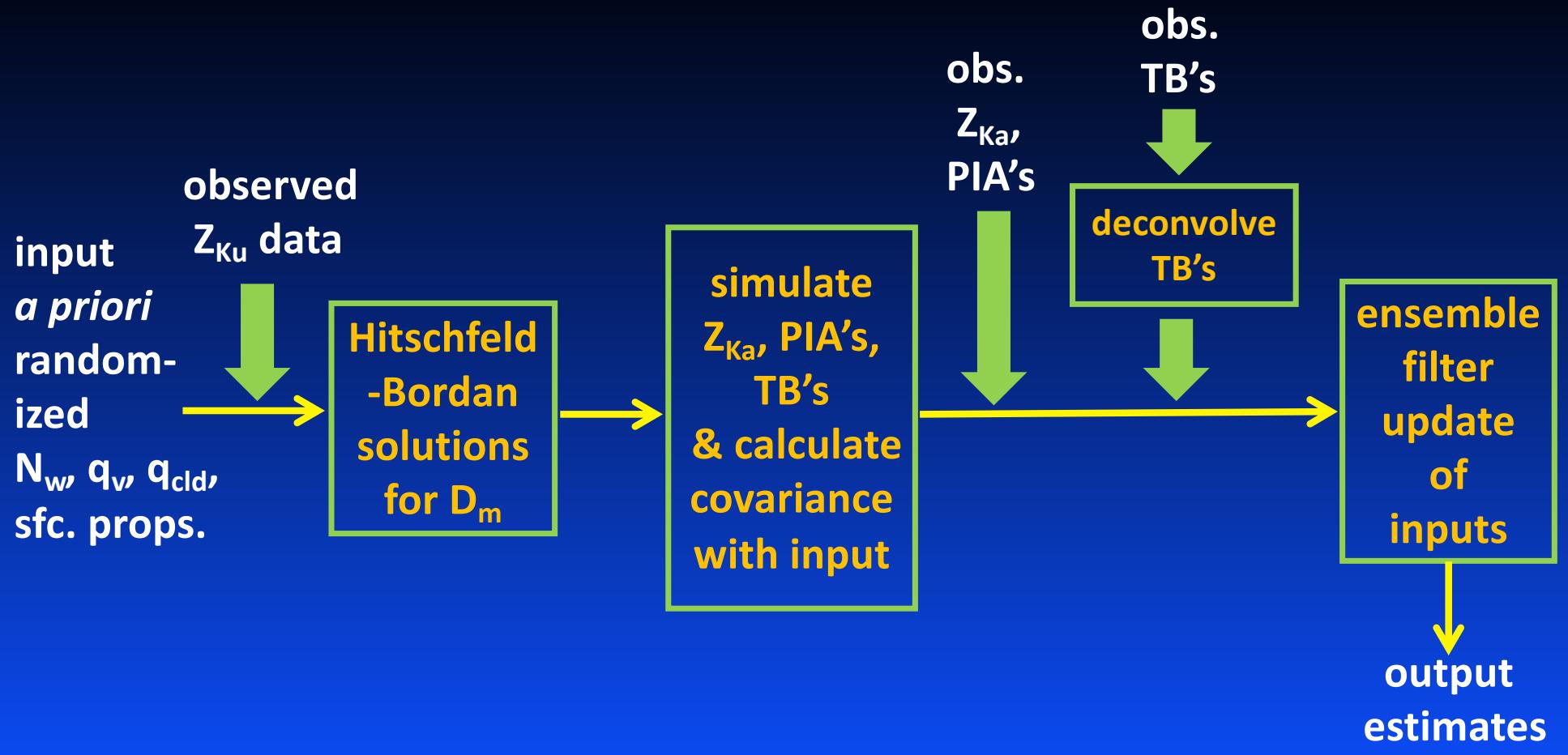
GPM V06 Error vs. MRMS (0.5°)



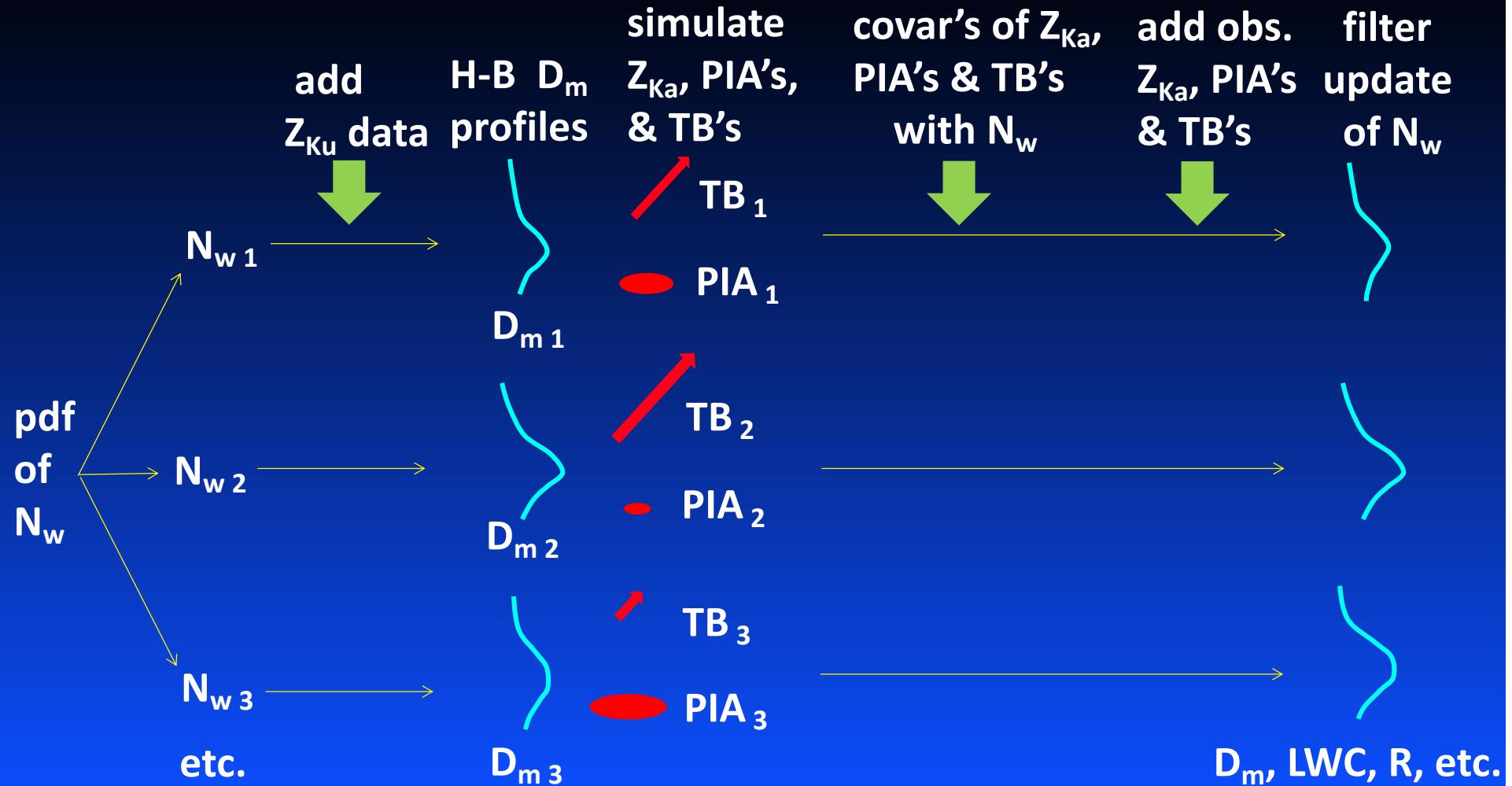
Synopsis, and Looking Ahead

- Succeeded in creating TRMM V08 algorithm that shares the same core as GPM V06.
- TRMM estimates sensitive to deconvolution; more testing needed.
- ◆ Radiometer-based estimates when radar signal fails to detect precip.
- ◆ Improved physics of ice/mixed-phase precipitation, multiple scat., etc.
- ◆ Need to link *a priori* assumptions to meteorological conditions – 2 step process.
- ◆ Outer swath HS Ka-band application will be implemented.

Combined Algorithm Block Diagram --- Ensemble Filter



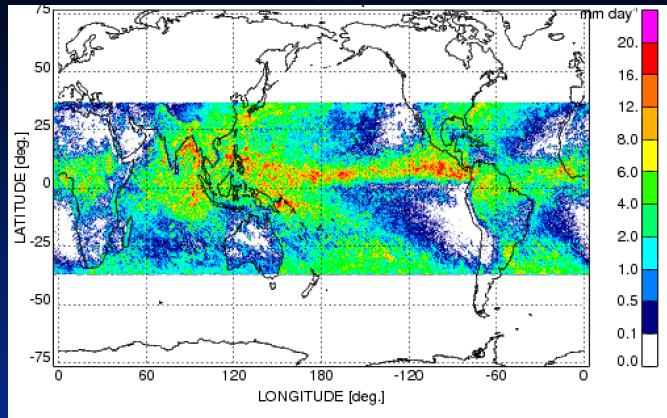
Algorithm “Concept” --- Ensemble Filter



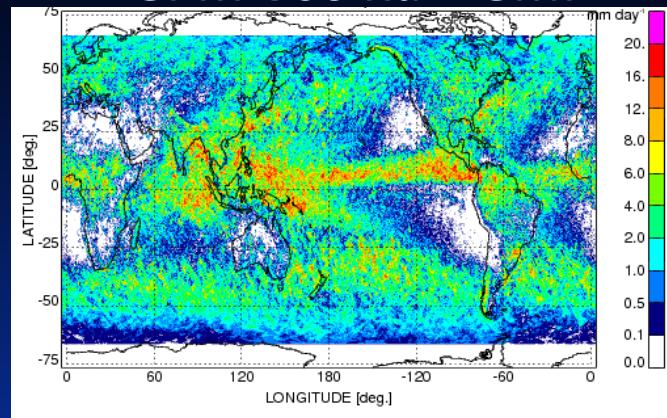
April – September, 2014, Average Plan Views

0.25°

TRMM V08 Ku + TMI

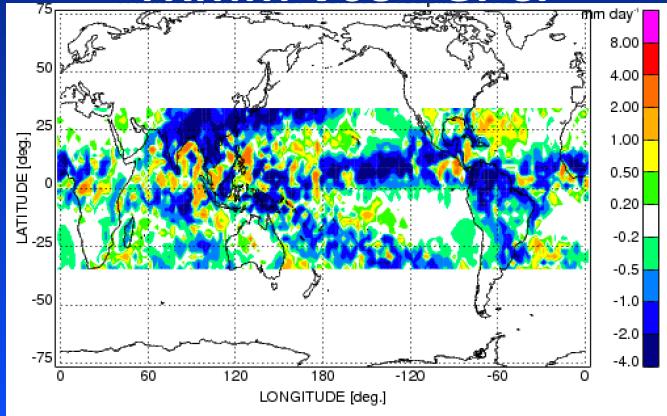


GPM V06 Ku + GMI

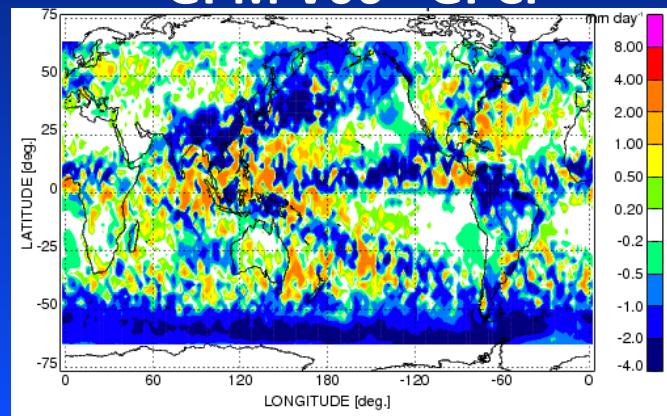


2.5°

TRMM V08 - GPCP

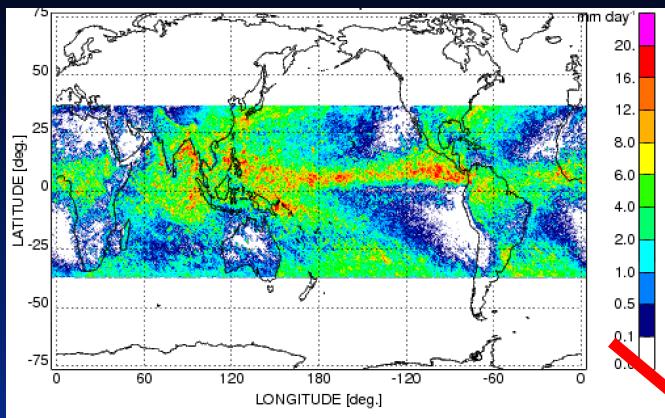


GPM V06 - GPCP



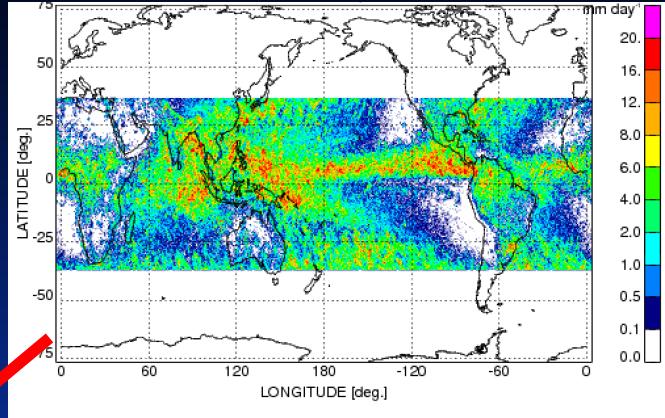
April – September, 2014, Average Plan Views

TRMM V08 Ku + TMI

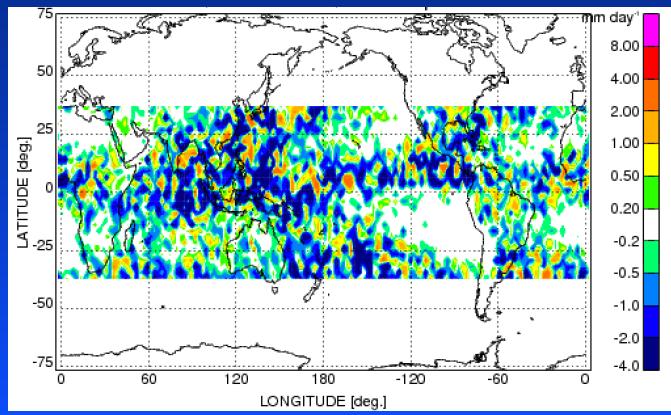


0.25°

GPM V06 Ku + GMI



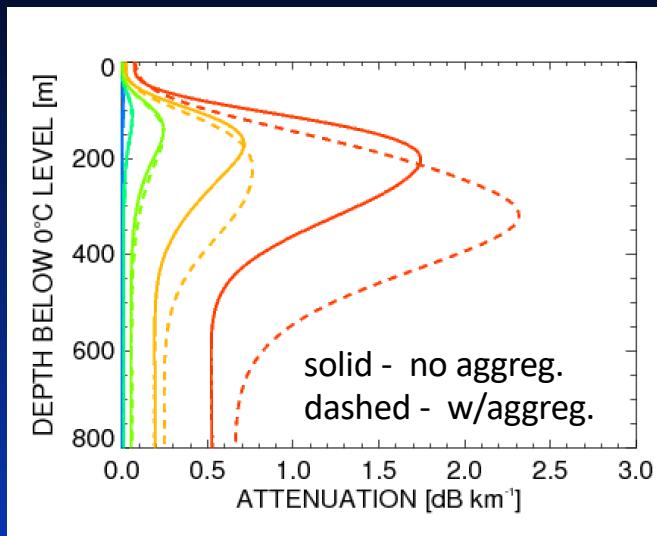
TRMM V08 – GPM V06



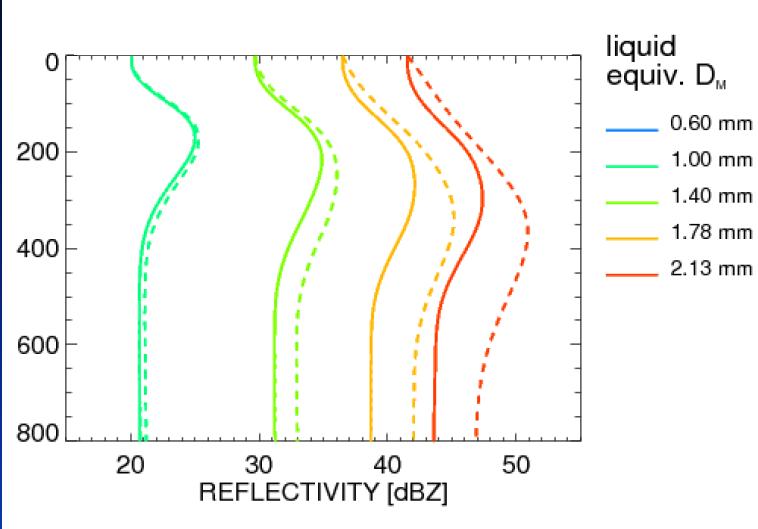
2.5°

Effect of Aggregation on Attenuation/Reflectivity

13.6 GHz Attenuation



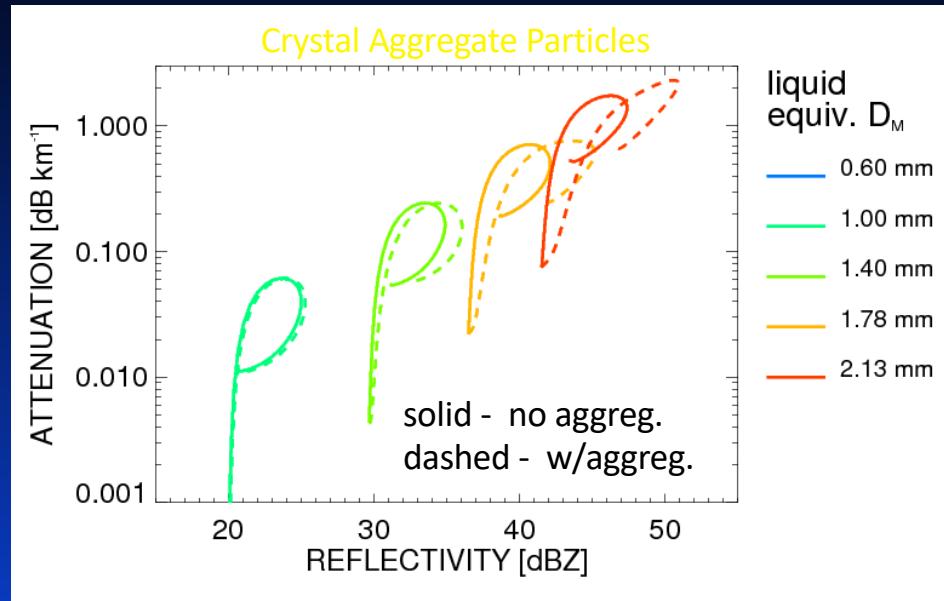
13.6 GHz Atten. Reflectivity



solid- no aggregation
dashed- with aggregation

Effect of Aggregation on Attenuation/Reflectivity

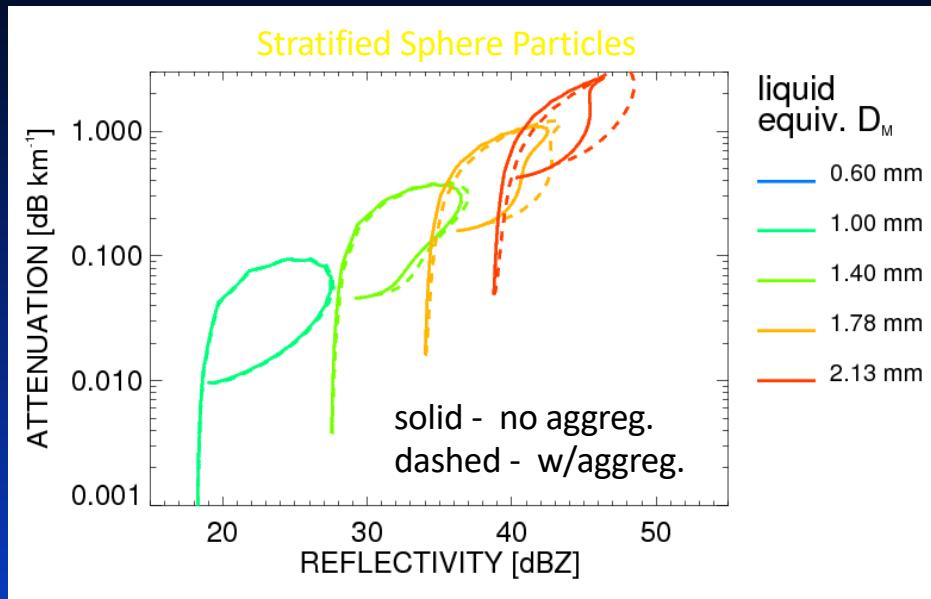
13.6 GHz Attenuation vs. Reflectivity



solid- no aggregation
dashed- with aggregation

Effect of Aggregation on Attenuation/Reflectivity

13.6 GHz Attenuation vs. Reflectivity



solid- no aggregation

dashed- with aggregation